Petrographic Study of Igneous Rocks and Breccias from the Mt. Bellview Prospect, Elk Mountains, Gunnison County, Colorado

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ABSTRACT

The Mt. Bellview prospect is located in the Elk Mountains of Gunnison County, approximately 12 miles north of Crested Butte, Colorado (Figure 1). Geologic mapping by Mutschler (1970) revealed that an igneous complex had intruded and hornfelsed the Mancos Shale in the Mt. Belleview area. The complex is Tertiary in age and consists of granodiorite, granodiorite porphyry, quartz monzonite porphyry, and a large body of intrusive igneous rubble breccia.

Petrographic study of the samples revealed prophylitic, argillic and phyllic hydrothermal alteration and/or silicification of the rocks of the Mt. Bellview stock. Geochemical studies revealed anomalous concentrations of Cu, Pb, Zn, Mo, Au and Ag in the rubble breccia pipe, higher than in the intrusive rocks.

Diamond drilling perhaps to a depth of 3000-4000 feet would adequately test the prospect as a potential site of porphyry molybdenum mineralization.

INTRODUCTION

The Mt. Bellview prospect is located in the Elk Mountains of Gunnison County, approximately 12 miles north of Crested Butte, Colorado. The area was visited by Professor D. E. Pride during August of 1974. Twenty seven hand specimens were collected for study. Locations of the samples collected, including some float debris, are indicated on Figure 1. Nineteen of the samples were examined petrographically during the study.

The purpose of this study is to compare the data compiled against current literature concerning porphyry deposits, noting especially the type and extent of hydrothermal alteration plus any associated

mineralization.

LABORATORY STUDIES

Specimen preparation included the making of standard thin sections and polished surfaces at The Ohio State University. Rock chips from which the thin sections were to be made were mounted on glass slides with Hiliquist epoxy, after having been rough-ground on steel laps with 200, 400 and 600 silicon carbide abrasives. Specimens were then taken down with a thin section grinder, periodi cally checking thickness with a petrographic microscope. Sections had to be finished by polishing on a glass plate with 600 silicon carbide abrasive. When 30 micron thickness was attained, glass cover slips were applied also using Hiliquist epoxy.

Two polished sections were made from specimens D-22 and D-F in order to examine metallic ore minerals present in many of the samples, in particular the breccias. Specimens were chosen according to the amount of opaque mineral observed in thin section. Sections were sawed, trimmed and shaped to approximately 3.0cm to 4.0cm in diameter. Samples were given a flat surface by rough grinding on steel laps with 120, 200, 400, and 600 silicon carbide abrasives. Rough polishing was done with a $303\frac{1}{2}$ and 305 emery on stainless steel laps. Sections were then polished on nylon-covered laps with 6 micron, 1 micron and $\frac{1}{4}$ micron diamond abrasives. Surfaces were buffed with $Ce0_2$ on microcloth on glass to remove any dirt and/or abrasive

The thin sections and polished surfaces studied were augmented, when necessary, by hand specimen observation. These were useful especially during the examination of the intrusive rubble breccia.

REGIONAL GEOLOGY

The Mt. Bellview prospect lies directly southeast of the nose of the Schofield Syncline. The Elk Range Thrust Fault, with a regional dip of 37° to the east-southeast, is located to the north of the mountain. Also directly north is the Maroon Formation which is a Pennsylvanian-Permian interbedded arkosic siltstone and cobble conglomerate, affected by minor thrust faults trending northwest-southeast. Tertiary granodiorite porphyry and quartz monzonite porphyry crop out in a northeasterly-southwesterly direction throughout the area. The Mancos Shale, Cretaceous in age, crops out to the west and southwest of the mountain. Dike-like intrusions of the Tertiary granodiorite porphyry and quartz monzonite porphyry crop out in the shale in a northwest-southeasterly direction (Mutschler, 1970).

LOCAL GEOLOGY

As mapped by Mutschler, much of the bedrock immediately surrounding Mt. Bellview is obscured by Quaternary deposits. The complex includes, however, the hornfelsed Mancos Shale, Tertiary bodies of granodiorite, granodiorite porphyry and quartz monzonite porphyry and an intrusive rubble breccia.

Mt. Bellview itself is a Tertiary felsite intrusion which brecciated the surrounding bedrock and hornfelsed the upper member of the Mancos Shale. Finger-like intrusions of quartz monzonite-quartz latite porphyry and Lincoln-type quartz monzonite porphyry cross cut the rubble breccia pipe in a northeasterly direction. Intrusion of the breccia resulted in a hornfelsed aureole of Mancos Shale, which crops out to the east, north and southwest of the mountain.

The strike of the shale varies greatly, but regionally the beds are overturned and dip 70° to the north-northeast. Tertiary porphyry and granodiorite crop out to the west-northwest of Mt. Bellview (Figure 1).

The age relationships of the breccia pipe and the accompanying intrusive bodies are vague other than to say that the lamprophyre (quartz monzonite-quartz latite porphyry) and Lincoln-type quartz monzonite porphyry apparently pre-dated the formation of the rubble breccia pipe. Intrusive relationships between the breccia and the granodiorite body to the northwest are obscure (Summary Report, Mt. Bellview).

QUARTZ MONSONITE PORPHYRY-QUARTZ LATITE PORPHYRY

The quartz monzonite-quartz latite porphyry samples were collected from the dike-like intrusion which crops out in the north central portion of the rubble breccia pipe. This rock is designated 'lamprophyre' (Figure 1). These specimens contain phenocrysts of plagioclase (andesine), orthoclase, biotite, amphibole and quartz. The quartz averages 1.0mm to 1.5mm in length, and the plagioclase crystals measure over 3.0mm long. The phenocrysts are set in a semi-aphanitic groundmass of quartz and potassium feldspar. Secondary minerals include pyrite, hematite (specularite), quartz and magnetite. Apatite, sphene and zircon constitute the accessory minerals.

Both hydrothermal alteration and weathering have affected the quartz monzonite-quartz latite porphyry samples. Chloritization of the biotite, kaolinization, seriticization, and/or epidotization of the feldspars, oxidation of the ferromagnesium minerals, and the

introduction of quartz and iron into the system was observed. Secondary iron is in the form of pyrite, hematite and/or magnetite.

GRANODIORITE-GRANODIORITE PORPHYRY (?)

The granodiorite-granodiorite porphyry(?) specimens, D-20 and D-21 respectively, were collected from the northern portion of the area studied. D-20 was collected near the contact between the lamprophyre and the Quaternary talus, and is moderately to severely hydrothermally altered (Figure 1). Constituents of the two rocks include orthoclase, plagioclase, quartz, biotite and traces of pyroxene. The interlocking crystals are euhedral to subhedral in habit with approximately 30% of the quartz marred by embayment. D-21 contains an euhedral plagioclase crystal 2.5cm x1.3cm x 3.0cm. Secondary minerals include hematite, magnetite and/or pyrite. The accessory minerals are euhedra of apatite, zircon and sphene.

Alteration effects include chloritization of the biotite, epidotization, seriticization and/or carbonatization of the feldspars, and addition of iron as hematite, magnetite and/or pyrite.

LINCOLN-TYPE QUARTZ MONSONITE PORPHYRY

The Lincoln-type quartz monzonite porphyry occurs as scattered Outcrops in the Mt. Bellview area (Figure 1). The rock samples are slightly to moderately altered by hydrothermal fluids and/or weathering. The phenocrysts include quartz occurring mostly as resorbed grains, plagioclase subhedra with weak to distinct zoning, orthoclase, biotite and/or amphibole. These phenocrysts are contained in a semi-aphanitic groundmass of quartz and feldspar. Secondary minerals are quartz, pyrite, hematite and minor pyrrhotite(?). Minor constituents include zircon, apatite and sphene.

Hydrothermal alteration produced chlorite and penninite from the biotite and/or amphibole, and sericite, kaolinite and/or minor epidote from the feldspars. Weathering of the ferromagnesium minerals resulted in the iron oxides present. Introduced into the rock were silica in the form of quartz and iron in the form of pyrite, hematite and pyrrhotite(?).

INTRUSIVE IGNEOUS RUBBLE BRECCIA

The samples collected from the Tertiary breccia pipe include D-3, D-5, D-10, D-12, D-13, D-16, and D-18 (Figure 1). Even though the body is very heterogenous, the overall appearance of the breccia does not change much from place to place (Figures 2-7). The probable former felsite matrix is now carbonate (calcite), wollastonite, clinozoisite, garnet (grossularite), epidote, quartz, pyrite, hematite, specular hematite, chlorite, amphibole, pyroxene (diopside), apatite, zircon and clay minerals. All but one of the hand specimens contain rounded to sub-rounded fragments of upper Cretaceous Mancos Shale, most of which show bedding. These fragments range in size from less than 1.0cm to over 3.5cm in length, as observed in hand samples. Field observation of the breccia pipe recorded fragments generally smaller than 12.7cm in diameter, but the rock fragments range in size up to 0.5m in diameter (Figures 3, 4, 5, 6). Smaller, angular fragments of igneous intrusives, including quartz monzonite-quartz latite porphyry and Lincoln-type porphyry, are present in several hand samples. These fragments are severely altered as observed in thin section. Five of the rubble breccias were slightly to moderately silicified.

UPPER CRETACEOUS MANCOS SHALE

Intrusion of the felsite body resulted in a hornfelsed aureole

of Mancos Shale. Although the two specimens are located relatively the same distance from the felsite, D-14 is more severely altered than D-2. D-2 is a fine-grained fissile shale containing quartz, potassium feldspar, scapolite, epidote and minor pyroxene. Bedding is prominent and appears to be disturbed only by cross-cutting veinlets of secondary quartz. D-14 is a medium-grained contact metamorphic rock whose constituents include calcite, scapolite exhibiting perfect sector twinning, epidote and/or idocrase, quartz and sphene.

DISCUSSION OF DATA

Mt. Bellview is a potential porphyry molybdenum deposit at a high level of erosion. Probable formation includes intrusion of a wet acidic or intermediate stock followed by the cooling of the upper part of this stock. Fracturing and shattering of the upper portion of the intrusion, as a result of cooling, then takes place, often involving the surrounding country rock. Fluids rise into the fractured rock, hydrothermally altering it and often depositing quartz, sericite, sometimes orthoclase, etc., as well as pyrite, chalcopyrite, bornite and other sulfides. These introduced minerals fill the closely spaced fractures and replace parts of the intrusion and the wallrock. The end of the cycle is marked by erosion, oxidation and/or supergene enrichment, (after Emmons, 1940).

The Mt. Bellview prospect is typical of most porphyry molybdenum deposits in that this Tertiary complex is associated with acidic host rocks of quartz monzonite-quartz latite porphyries; the complex is one of multiple intrusions; and the system includes several

porphyry phases which occur late in the intrusion sequence. These phases are important because they are thought to relieve much of the confined pressure and are good indicators of mineralization.

Hydrothermal alteration of the type associated with porphyry systems is present at Mt. Bellview. These include a propylitic zone encompassing the area associated with specimens D-5, D-10, D-13, D-16, D-18(?), D-20, and D-14. Minerals present as the result of hydrothermal alteration include chlorite, epidote and calcite. This zone is located within the area mapped as intrusive rubble breccia. Near the periphery of the propylitic zone, farther out from the breccia pipe, alteration products include potassium feldspar, sericite and/or kaolinite. This argillic zone consists of Lincoln-type quartz monzonite porphyry (D-8 and D-17) and lamprophyre (D-4 and D-15). The outermost zone, in the case of this Tertiary intrusive complex, is a phyllic zone of alteration whose minerals include quartz, sericite, pyrite and chlorite. Samples comprising this zone include D-3, D-12, D-22, D-18, D-21, D-1 and D-9. The presence of these various minerals as products of hydrothermal alteration is due to the relatively large volumes of hydrothermal fluids percolating through the system, altering the wallrock and/or introducing new minerals into the complex, in particular iron and silica. The intrusive rubble breccia indicates the evolution of this vast amount of hydrothermal fluid.

Mineralization within the complex is present as disseminated masses of metallic ore minerals with the enrichment, if present, occurring in the intrusive rubble breccia matrix and the late stage quartz monzonite porphyry dikes. Geochemical analysis data of composite rock-chop samples for Cu, Pb, Zn, Mo, Au and Ag are given

in Table 1. Whereas the average concentrations for the chosen elements are not high, the rocks exposed at Mt. Bellview may comprise the upper portion of the intrusive complex and only low concentrations, in particular of molybdenum, might be expected. In light of present models of porphyry mineralization, anomalous concentrations of the elements may exist at depth (Summary Report, Mt. Bellview).

CONCLUSIONS

The Mt. Bellview area, because of the presence of the intrusive rubble breccia and pervasive hydrothermal alteration and mineralization, is a promising prospect for porphyry molybdenum mineralization. Drilling to a depth of 3000 to 4000 feet would adequately test the deposit for deep seated mineralization.

Specimen number: D-1

Rock type: Quartz latite porphyry

Specimen summary description: Holocrystalline, inequigranular slightly fractured quartz latite porphyry whose phenocrysts of biotite, amphibole, plagioclase and orthoclase are set in a semi-aphanitic groundmass of quartz and potassium feldspar. The euhedral to anhedral grains range in size from less than 0.2mm to over 3.0mm averaging 1.0mm to 1.5mm in size.

Thin section description:

40% Plagioclase which occurs as euhedral to subhedral grains ranging in size from 0.2mm to over 2.0mm in length. Prominent Carlsbad-Albite twinning is present in nearly all grains, however determination of An composition was impossible in this section due to grain orientation. Grains are slightly to moderately seriticized and/or kaolinized. Minor epidotization was also observed. Zoning of the plagioclase is weak to distinct.

30% Orthoclase which is present as subhedral to anhedral crystals averaging 1.0mm in longitudinal sections. Very minor seriticization is present on several of the grains.

11% Biotite which is present as subhedral to anhedral grains from 0.75mm to 1.5mm in length. All grains are pleochroic from pale yellow to tan to brown. All contain inclusions of euhedral apatite and/or pyrite. Moderate to extreme chloritization was observed. The chlorite is strongly pleochroic in green. Several grains appear to be penninite and show anomolous interference colors.

13% Quartz occurring as microcrystalline subhedral grains, which together with the potassium feldspar, constitute the groundmass.

Minor amphibole was noted in close association with the biotite.

Opaque minerals include hematite, specular hematite, pyrite and goethite and make up 6% of the rock. The hematite and pyrite occur as disseminated masses in the groundmass while the specularite and goethite are present as secondary vein filling minerals. Iron oxides are the result of weathering of the ferromagnesium minerals.

Specimen number: D-2

Rock type: Hornfelsed Mancos Shale

Specimen summary description: Slightly altered grey-green fissile shale showing prominent bedding. The bedding is cross-cut by minute veinlets of secondary quartz. The rock is very fine-grained.

Thin section description:

73% Quartz is present as clay-size anhedral grains. Veinlets of secondary quartz cross-cut the bedding in the shale.

10% Potassium feldspar occurs as interlocking grains with very minor epidotization present on several grains.

10% Scapolite is present as colorless aggregates often exhibiting sector twinning.

7% Pyroxene (diopside?) is present as prismatic crystals closely associated with the scapolite.

Specimen number: D-3

Rock type: Intrusive igneous rubble breccia

Specimen summary description: Slightly fractured intrusive igneous rubble breccia whose constituents include calcite, wollastonite, quartz, hematite, pyrite and small angular rock fragments. The fragments are igneous in nature but rock type determination was impossible.

Thin section description:

73% Calcite occurs as colorless fine-grained aggregates containing inclusions of wollastonite.

10% Wollastonite is present as turbid columnar to radial aggregates whose poikiloblastic texture is due to minute gaseous and/or liquid inclusions. Simple twinning and weak zoning (2-3 zones) were observed. All the wollastonite is in close association with the carbonate, i.e. the silicate is enveloped in the calcite.

10% Opaque minerals include patches of hematite (specularite?) and disseminated subhedral to anhedral pyrite.

7% Quartz occurs as a secondary interstitial mineral and as a fracture filler.

Specimen number: D-4

Rock type: Quartz latite porphyry

Specimen summary description: Slightly altered quartz latite porphyry containing phenocrysts of plagioclase, amphibole, orthoclase and quartz set in a semi-aphanitic groundmass of quartz and potassium feldspar.

Thin section description:

37% Plagioclase occurring as euhedral to anhedral crystals ranging in size from less than 0.5mm to 3.0mm. Carlsbad twinning and weak to very distinct zoning (up to 10 zones) are present. Sericitic alteration is more severe at phenocrysts peripheries than at the cores. Smaller grains (1.0mm-1.5mm) exhibit extensive seriticization. An composition is indeterminent.

30% Orthoclase is present as euhedral to anhedral crystals averageing 1.0mm in length. All grains are extremely seriticized and/or kaolinized.

18% Quartz occurs as anhedral interstitial grains, slightly fractured anhedral phenocrysts 3.0mm in size, and as inclusions in the amphibole and hematite.

10% Amphibole is present as euhedral to subhedral pleochroic grains averaging 0.5mm in length. Pleochroism is yellowish green to moss green. Most of the grains are poikilitic and contain inclusions of quartz, euhedral apatite and/or opaque mineral. Over 50% of the amphibole individuals are twinned. Very minor epidote after the amphibole was observed to contain minute quartz inclusions.

5% Opaque minerals include disseminated hematite containing minute pyrite inclusions.

Accessory minerals present are sphene, ziron and apatite.

Specimen number: D-5

Rock type: Silicified igneous rubble breccia

Specimen summary description: Silicified igneous rubble breccia whose constituents include sub-rounded to well-rounded Mancos Shale fragments up to 3.5cm in length as observed in hand specimen, igneous rock fragments, epidote, clinozoisite, quartz, calcite, grossularite, wollastonite, hematite and pyrite.

Thin section description:

43% Clinozoisite is present as euhedral to subhedral bladed crystals arranged in radial patterns and as irregular intergrowths with epidote.

13% Quartz occurs as interstitial grains and as secondary mineral filling the veinlets.

13% Grossularite is present as euhedral to subhedral crystals many of which are distinctly zoned (3-4 zones). Minor epidotization was observed. Epidote is pleochroic form pale yellow to greenish-yellow and occurs as somewhat columnar aggregates throughout the breccia.

12% Calcite occurs as a fine-grained aggregate and as a minor constituent in the veinlets.

9% Wollastonite is present as rectangular laths with a turbid appearance due to liquid and/or gaseous inclusions. Minor twinning was observed.

5% Opaque minerals which include specular hematite and subhedral pyrite, both of which occur as disseminated patches in the rock.

5% Rock fragments which include Upper Cretaceous Mancos Shale and igneous fragments. Many of the shale fragments display bedding. The igneous rock pieces are angular-sub-angular in shape and are probably Lincoln-type quartz monzonite porphyry.

Specimen number: D-8

Rock type: Lincoln-type quartz monzonite porphyry

Specimen summary description: Slightly altered holocrystalline quartz monzonite porphyry whose constituents are quartz, plagioclase, orthoclase, biotite, minor amphibole, pyrite, and pyrrhotite(?) in a semi-aphanitic groundmass of quartz and potassium feldspar.

Thin section description:

35% Plagioclase which is present as 3.0mm to 3.5mm rectangular laths with weak to distinct zoning and prominent Carlsbad-Albite twins. The twinning and zoning are obscured by seriticization. An composition was again unobtainable.

30% Orthoclase occurs as subhedral crystals ranging in size from 2.0mm to over 1.0cm the average being 2.0mm-3.0mm. Partial (at grain boundaries) to complete seriticization and/or kaolinization is present.

16% Quartz occurs as 1.0mm to 1.5mm phenocrysts whose outlines are marred by embayment. Interstitial quartz is also present.

12% Biotite anhedra are pleochroic from tan to dirty brownish-yellow and contain inclusions of euhedral apatite and subhedral zircon. The iron oxides are the result of weathering.

5% Pyrite and pyrrhotite(?) which occur as disseminated masses.

2% Amphibole is present in the rock as green anhedral grains.

Specimen number: D-9

Rock type: Quartz monzonite porphyry

Specimen summary description: Holocrystalline quartz monzonite porphyry whose phenocrysts of quartz, plagioclase (andesine), biotite and orthoclase are set in a matrix of quartz and feldspar. Minor constituents of the rock include pyrite, magnetite, apatite and zircon.

40% Plagioclase is present as subhedral grains exhibiting distinct Carlsbad-Albite twins. An composition of An_{38}-An_{40} was determined using the Michel-Levy Method on 12 different grains. The plagioclase subhedra range in size from 0.5mm to 2.5mm with the average length being 1.0mm. Weak zonation is present together with very minor sericitization.

28% Orthoclase occurs as subhedral to anhedral grains averaging 1.0mm in longitudinal sections. Grains are slightly to moderately hydrothermally altered to sericite.

18% Quartz occurs as both a primary and secondary mineral. Primary quartz anhedra range in size from less than 0.5mm to 4.0mm and are greatly marred by resorption. Secondary quartz is present as subhedral to anhedral grains filling the fractures. Excellent cross-cutting relationships between the resorbed grains and the veinlets were observed.

9% Biotite is present as anhedral grains averaging 1.0mm in length and are pleochroic from pale yellowish-tan to chocolate brown. Very minor chloritization was observed. Included in the biotite are euhedral apatite crystals, subhedral pyrite, subhedral quartz and zircon as radiohaloes.

5% Opaque minerals which include disseminated pyrite and magnetite.

Specimen number: D-10

Rock type: Silicified igneous rubble breccia

Specimen summary description: Silicified igneous rubble breccia whose constituents include quartz, calcite, diopside, amphibole, wollastonite, grossularite, specular hematite and sub-angular Upper Cretaceous Shale fragments (as observed in hand specimen).

Thin section description:

53% Calcite is present as a very fine-grained aggregate often found enveloping the wollastonite.

16% Grossularite occurs as irregular masses often enveloped within a fibrous green fine-grained amphibole. Minor chloritization and epidotization were observed. The grossularite seems to be closely associated with the specular hematite in the absence of the amphibole. Inclusions of quartz, apatite and calcite are present in the garnet.

13% Wollastonite is present as columnar to radial aggregates closely associated with the calcite.

6% Amphibole occurs as a very fine-grained green aggregate strongly pleochroic from light green to emerald green.

5% Quartz anhedra occur secondarily as fracture fillers.

5% Specular hematite occurs as radial aggregates and as disseminated patches together with very minor traces of pyrrhotite.

2% Diopside is present as euhedral to subhedral prismatic crystals.

Specimen number: D-12

Rock type: Silicified igneous rubble breccia

Specimen summary description: Silicified igneous rubble breccia whose constituents include sub-angular igneous (quartz monzonite porphry?) rock fragments, calcite, wollastonite, quartz, diopside, garnet (grossularite?) and pyrite.

Thin section description:

38% Wollastonite is found as interlocking aggregates closely associated with calcite.

29% Calcite occurs as a very fine-grained aggregate which is polysynthetically twinned and as a secondary vein mineral. The carbonate is closely associated with the columnar wollastonite.

12% Diopside is present as fibrous aggregates in radial arrangements.

10% Garnet (grossularite?) is present as subhedral to anhedral dark brown crystals containing inclusions of quartz.

6% Quartz occurs as secondary euhedral to anhedral interlocking grains and as minor anhedral inclusions (or replacement of?) in the calcite.

5% Pyrite occurs as disseminated euhedra.

Specimen number: D-13

Rock type: Silicified intrusive rubble breccia

Specimen summary description: Silicified intrusive rubble breccia whose constituents include quartz, calcite, diopside, amphibole, grossularite, specular hematite and angular to sub-angular Upper Cretaceous Mancos Shale fragments.

Thin section description:

48% Calcite which occurs as very fine-grained aggregates enveloping traces of wollastonite.

14% Grossularite occurs as irregular masses closely associated with fibrous green amphibole. Minor chlorite and epidote after the grossularite were observed. Inclusions of quartz, apatite and calcite are present in the garnet.

10% Quartz is present as secondary vein mineral.

10% Rock fragments of Mancos Shale were noted.

8% Specular hematite is present as weak resettes often associated with the grossularite.

5% Diopside occurs as euhedral to subhedral prismatic crystals.

5% Amphibole occurs as a very fine-grained fibrous green aggregate strongly pleochroic in green.

Specimen number: D-14

Rock type: Hornfelsed Mancos Shale

Specimen summary description: Moderately altered medium-grained hornfelsed Mancos Shale whose constituents include calcite, quartz, scapolite, epidote and/or idocrase, and minor sphene.

Thin section description:

40% Quartz occurs as subhedral to anhedral interlocking grains.

33% Calcite is present as colorless turbid very fine-grained aggregates with distinct polysynthetic twins.

18% Scapolite is present as columnar aggregates displaying perfect sector twinning.

9% Epidote and/or idocrase are both present as fine-grained aggregates associated with the calcite.

Sphene is present as an accessory mineral.

Specimen number: D-15

Rock type: Quartz monzonite porphyry

Specimen summary description: Holocrystalline slightly altered quartz monzonite porphyry whose phenocrysts include amphibole, plagioclase, orthoclase and quartz in a matrix of quartz and potassium feldspar. Weathering of the ferromagnesium minerals resulted in the iron oxide staining.

Thin section description:

35% Plagioclase lath-shaped grains are distinctly twinned according to the Carlsbad-Albite Law. Distinct zoning with 6 or more zones is present. Very, very minor seriticization, if at all, is at grain peripheries. Composition of the plagioclase feldspar is An_{36}-An_{42} using the Carlsbad-Albite method of determination.

23% Amphibole occurs as euhedral to anhedral crystals which are pleochroic from tan to moss green and from tan to orangish-brown. Approximately 30% of the individuals are twinned. All grains contain inclusions of apatite and/or zircon. Another variety of amphibole present is a fibrous fine-grained green aggregate pleochroic in shades of light green.

22% Orthoclase anhedra display Carlsbad twinning and minor to moderate seriticization and/or kaolinization. Several individuals are completely kaolinized. Minor to severe epidotization was also noted.

15% Quartz occurs as anhedral phenocrysts.

5% Hematite is present as disseminated masses.

Euhedral sphene as an accessory mineral is present.

Specimen number: D-16

Rock type: Silicified igneous rubble breccia

Specimen summary description: Silicified igneous rubble breccia composed of angular Mancos Shale fragments (as observed in hand specimen, grossularite, specular hematite, pyrite, quartz, calcite and amphibole in a former felsite matrix which is now clay minerals.

Thin section description:

35% Grossularite which occurs as euhedral to anhedral crystals which have been severely epidotized. The epidote is yellowish-green and is of fibrous habit. Minor chloritization of the garnet was also noted.

20% Clay Mineral, as the result of hydrothermal alteration of the Igneous rock fragments, is present.

15% Epidote as an alteration product of feldspars(?) and garnet was observed.

10% Calcite is present as a very fine-grained turbid aggregate containing inclusions of quartz euhedra and minor apatite.

8% Amphibole occurs both as granular aggregates pleochroic from light yellowish-green to emerald green, and as fibrous green aggregates. Both varieties contain inclusions of zircon and/or apatite. Iron oxide stain, due to weathering, was also noted.

7% Opaque minerals include specular hematite which occurs as radiating structures, and pyrite euhedra scattered throughout the breccia.

3% Chlorite as an alteration product is present.

2% Quartz occurs as secondary euhedral to anhedral grains averaging less than 1.0mm in size.

Specimen number: D-17

Rock type: Lincoln-type quartz monzonite porphyry

Specimen summary description: Moderately altered Lincoln-type quartz monzonite porphyry whose phenocrysts average 1.0mm to 1.5mm in size and include amphibole, plagioclase, quartz and orthoclase in a groundmass of euhedral to anhedral quartz and potassium feldspar.

Thin section description:

33% Plagioclase subhedra exhibiting weak twinning and zoning both of which are masked by alteration to kaolinite, sericite and/or chlorite. Minor epidotization of the feldspar was also noted.

30% Orthoclase anhedra are completely kaolinized.

15% Quartz is present as anhedral phenocrysts and as secondary mineral.

15% Amphibole occurs in two distinct habits. First as euhedral to anhedral pleochroic grains of which over 50% are simply twinned. These phenocrysts contain inclusions of quartz, zircon and/or apatite euhedra. Minor chlorite after the amphibole is present. The second habit is a fine-grained green fibrous aggregate.

7% Hematite occurs as subhedral to anhedral grains containing euhedral zircon inclusions.

Specimen number: D-18

Rock type: Silicified igneous rubble breccia

Specimen summary description: Silicified igneous rubble breccia whose constituents include Upper Cretaceous Mancos Shale fragments (observed only in hand specimen), grossularite, clinozoisite, calcite, pyrite, hematite, quartz and wollastonite. The sub-angular shale fragments show sub-parallel bedding.

Thin section description:

61% Grossularite is present as euhedral to subhedral crystals of which over 80% are zoned. Several euhedral grains display up to 6 or 7 distinct zones. Minor epidotization is present.

10% Quartz is a secondary mineral filling the veinlets.

10% Calcite occurs as colorless fine-grained aggregates which are in close association with the wollastonite enhedra.

9% Clinozoisite occurs as colorless columnar aggregates arranged in somewhat radial patterns.

5% Wollastonite is present as anhedral grains enveloped within the calcite.

5% Hematite and/or pyrite both of which occur as disseminated anhedra are present.

Specimen number: D-20

Rock type: Granodiorite

Specimen summary description: Holocrystalline equigranular moderately altered granodiorite whose constituents include orthoclase, plagioclase, quartz and minor trace of pyroxene. The interlocking grains exhibit minor to moderate hydrothermal alteration and minor weathering.

Thin section description:

35% Quartz occurs as euhedral to anhedral grains most of which are marred by resorption. Over 85% of the quartz contains inclusions of apatite.

33% Plagioclase is present as euhedral to subhedral crystals whose zoning and twinning are obscured by sericitic alteration. Very minor traces of carbonate after the plagioclase were noted. Other hydrothermal alteration products include minor epidote and clinozoisite.

15% Chlorite occurs as the result of hydrothermal alteration of the ferromagnesium mineral. Chlorite is pleochroic in pale mint greens. Minor penninite with anomolous Berlin blue interference color is also present. The chlorite and penninite both contain inclusions of zircon euhedra.

9% Orthoclase is present as subhedral grains which are slightly to moderately kaolinized and/or seriticized and which contain inclusions of euhedral apatite.

7% Hematite and magnetite are present as euhedral to subhedral crystals.

1% Pyroxene is present as radial aggregates.

Specimen number: D-21

Rock type: Granodiorite porphyry(?)

Specimen summary description: Holocrystalline inequigranular slightly altered granodiorite porphyry(?) whose constituents average 1.0mm to 2.0mm in size with one plagioclase phenocryst measuring 2.5cm x 1.3cm x 3.0cm (as measured in hand specimen). This euhedral zoned crystal constitutes approximately 45% of the thin section.

Thin section description:

54% Plagioclase is present as euhedral to subhedral crystals twinned on the Albite Law. Minor but distinct zoning is present. Alteration, if present, occurs as minor seriticization at grain peripheries. The large plagioclase crystal is simply twinned and distinctly zoned. Inclusions of euhedral quartz, plagioclase, orthoclase and subhedral biotite were noted. Very minor epidote is present.

23% Orthoclase occurs as subhedral grains with prominent Carlsbad twins and very little hydrothermal alteration to sericite.

12% Quartz occurs as euhedral to anhedral crystals most of which are marred by resorption.

8% Biotite is present as subhedral to anhedral grains pleochroic from pale yellow to muddy brown. Inclusions of euhedral zircon and zircon as radiohaloes were noted. Minor chloritization and weathering are present in some of the grains.

3% Pyrite and hematite occur as disseminated masses in the rock with the hematite subhedra often containing zircon euhedra.

Sphene euhedra occur as an accessory mineral.

Specimen number: D-22

Rock type: Lincoln-type quartz monzonite porphyry

Specimen summary description: Quartz monzonite porphyry whose phenocrysts of biotite, amphibole, plagioclase, orthoclase and quartz are set in a semi-aphanitic groundmass of quartz and potassium feldspar.

Thin section description:

27% Plagioclase subhedra exhibit very distinct Carlsbad-Albite twins and prominent zoning with up to 7 zones in several cases. Phenocrysts measure up to 1.3cm in the hand sample.

23% Orthoclase crystals are subhedral in habit and are very slightly seriticized at grain peripheries.

18% Biotite anhedra are present as highly chloritized grains containing inclusions of pyrite and/or hematite, zircon and apatite. Minor penninite is also present.

18% Quartz occurs as euhedral to anhedral interlocking grains some of whose outlines are marred by embayment.

9% Amphibole occurs as both euhedral to subhedral pleochroic grains which are simply twinned and as a fine-grained fibrous aggregate. Sphene is present as an accessory mineral.

Polished section description:

5% Opaque mineral which includes pyrite, hematite, goethite and magnetite.

Pyrite occurs as euhedral to anhedral crystals whose peripheries are being replaced by goethite. Several pyrite grains contain blebs of goethite.

Hematite occurs as both columnar aggregates and as distinct rosettes. In one case, the hematite is present as bladed crystals.

Magnetite is present as euhedral crystals containing pyrite euhedra or inclusions of gangue.

Specimen number: D-F

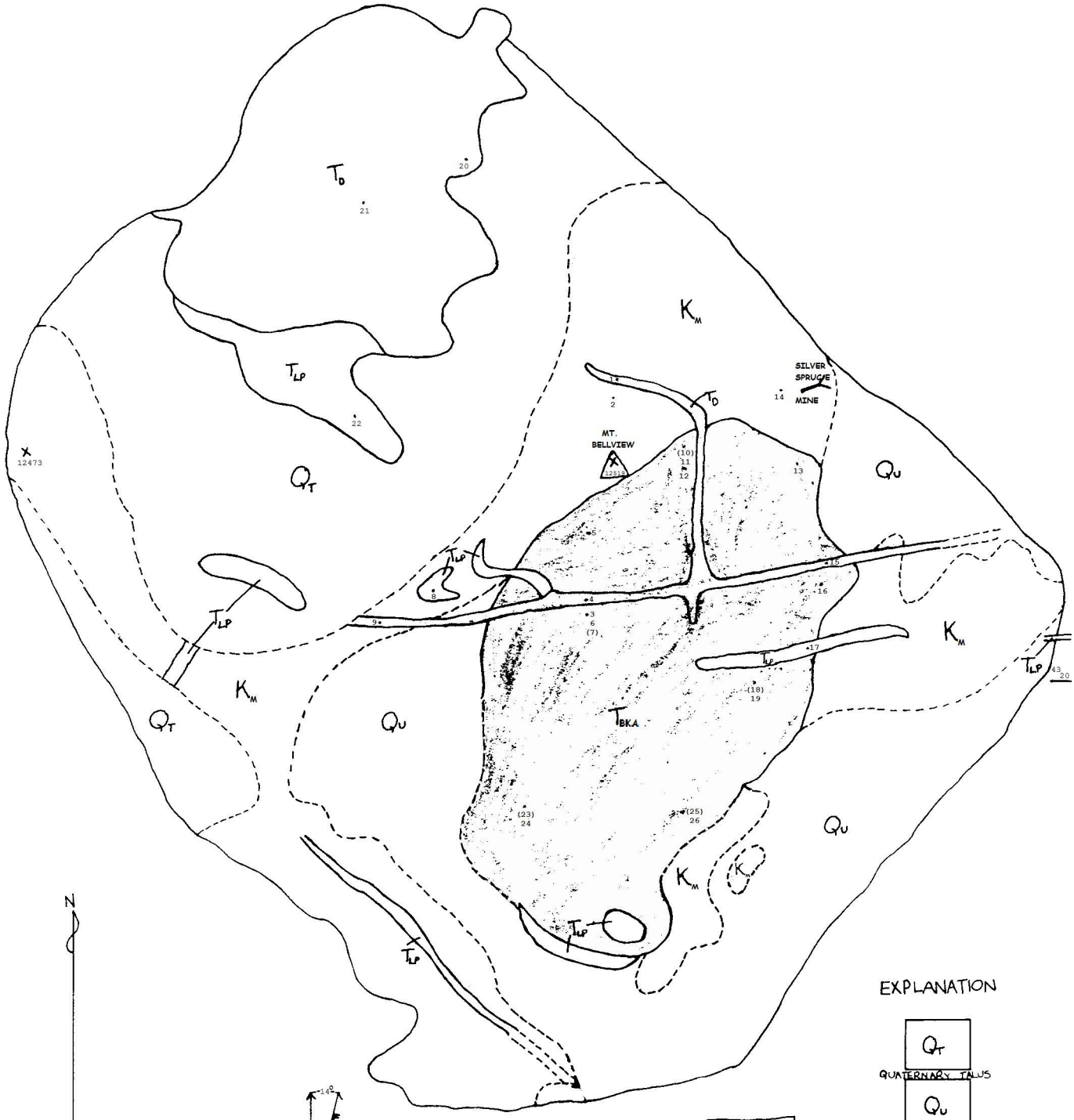
Rock type: Igneous rubble breccia

Specimen summary description: Float debris containing abundant patches of specular hematite.

Polished section description:

97% Specular hematite is present as weak to distinct rosettes and as bladed aggregates. Minor traces of pyrite subhedra are included in the hematite.

3% Gangue which is probably quartz and/or carbonate.



GEOCHEMICAL SAMPLE LOCATION - GENERAL GEOLOGY
MT. BELLVIEW PROSPECT
GUNNISON COUNTY COLORADO
(Snowmass Mountain 7'30" Quadrangle)

FIGURE 1

14 - Sample Location

(25) Two samples collected, 26 one each of matrix and fragments - pebble samples shown in ( ).

Figure 2: Intrusive rubble breccia pipe on SE slope of Mt. Bellview, Colorado.

Figure 3: Intrusive rubble breccia. Note angular Mancos Shale fragments.

Figure 4: Intrusion breccia, Mt. Bellview.

Figure 5: Intrusion breccia from the top of Mt. Bellview.

Figure 6: Intrusive rubble breccia from SE slope of Mt. Bellview. Note large Mancos Shale fragment.

Figure 7: Intrusive breccia fragment from the S slope of Mt. Bellview. Note the specular hematite.

GEOCHEMISTRY VS. ROCK TYPE (ppm)

Rock type	Sample no.	Cu	Pb	Zn	Mo	Au	Ag
Lincoln Porhph.	8	65	10	20	10	--	--
	17	10	5	15	4	--	--
	22	30	10	15	4	--	--
Breccia Pipe							
matrix	7	15	5	15	4	--	--
	11	140	5	20	6	< .02	< .2
	19	15	5	10	22	--	--
	24	5	< 5	5	4	< .02	< .2
	26	40	5	20	6	< .02	< .2
fragments	6	10	5	30	4	< .02	< .2
	23	5	< 5	5	4	--	--
	25	30	5	20	6	< .02	< .2
matrix & fragments	3	30	5	15	4	--	--
	5	20	10	15	4	--	--
	10	45	5	20	4	--	--
	12	35	15	320	6	--	--
	13	65	5	15	6	--	< .2
	16	290	5	20	4	--	--
	18	10	< 5	15	10	--	--
Monzonite	1	155	10	15	18	--	.8
Porphyry	4	5	5	15	2	--	--
	9	60	10	55	8	--	--
	15	35	10	20	6	--	--
Granodiorite	20	5	5	25	4	--	--
Porphyry	21	5	10	20	4	< .02	< .2
Hornfelsed Mancos Shale	2	50	5	30	6	--	--

TABLE I

BIBLIOGRAPHY

_____, "Summary Report: Geologic Reconnaissance and Geochemical Survey, Mt. Bellview Prospect, Elk Mountains, Gunnison County, Colorado".

Mutschler, F.E., Geologic map of the Snowmass Mountain Quadrangle, Pitkin and Gunnison Counties, Colorado: United States Geological Survey Map GQ-853, 1970.

Pride, D.E. and Robinson, C.S., "Multiple intrusion and hydrothermal activity, eastern Breckenridge mining district, Summit County, Colorado", Geological Society of America Bulletin, v. 89, pp. 866-874.

Wallace, S.R., et al., "Multiple intrusions and mineralization at Climax, Colorado" in Ore Deposits in the United States, 1933-1967 (Graton-Sales volumes), v.1, pp. 605-640, 1968.